Fishery Data Series No. 15-43

# Sonar Estimation of Summer Chum and Pink Salmon in the Anvik River, Alaska, 2014

by

**Jody D. Lozori**

November 2015

Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

## Symbols and Abbreviations

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**Weights and measures (metric)**

| | |
|---|---|
| centimeter | cm |
| deciliter | dL |
| gram | g |
| hectare | ha |
| kilogram | kg |
| kilometer | km |
| liter | L |
| meter | m |
| milliliter | mL |
| millimeter | mm |

**Weights and measures (English)**

| | |
|---|---|
| cubic feet per second | $ft^3/s$ |
| foot | ft |
| gallon | gal |
| inch | in |
| mile | mi |
| nautical mile | nmi |
| ounce | oz |
| pound | lb |
| quart | qt |
| yard | yd |

**Time and temperature**

| | |
|---|---|
| day | d |
| degrees Celsius | °C |
| degrees Fahrenheit | °F |
| degrees kelvin | K |
| hour | h |
| minute | min |
| second | s |

**Physics and chemistry**

| | |
|---|---|
| all atomic symbols | |
| alternating current | AC |
| ampere | A |
| calorie | cal |
| direct current | DC |
| hertz | Hz |
| horsepower | hp |
| hydrogen ion activity (negative log of) | pH |
| parts per million | ppm |
| parts per thousand | ppt, ‰ |
| volts | V |
| watts | W |

**General**

| | |
|---|---|
| Alaska Administrative Code | AAC |
| all commonly accepted abbreviations | e.g., Mr., Mrs., AM, PM, etc. |
| all commonly accepted professional titles | e.g., Dr., Ph.D., R.N., etc. |
| at | @ |
| compass directions: | |
| east | E |
| north | N |
| south | S |
| west | W |
| copyright | © |
| corporate suffixes: | |
| Company | Co. |
| Corporation | Corp. |
| Incorporated | Inc. |
| Limited | Ltd. |
| District of Columbia | D.C. |
| et alii (and others) | et al. |
| et cetera (and so forth) | etc. |
| exempli gratia (for example) | e.g. |
| Federal Information Code | FIC |
| id est (that is) | i.e. |
| latitude or longitude | lat or long |
| monetary symbols (U.S.) | $, ¢ |
| months (tables and figures): first three letters | Jan,...,Dec |
| registered trademark | ® |
| trademark | ™ |
| United States (adjective) | U.S. |
| United States of America (noun) | USA |
| U.S.C. | United States Code |
| U.S. state | use two-letter abbreviations (e.g., AK, WA) |

**Mathematics, statistics**

| | |
|---|---|
| *all standard mathematical signs, symbols and abbreviations* | |
| alternate hypothesis | $H_A$ |
| base of natural logarithm | *e* |
| catch per unit effort | CPUE |
| coefficient of variation | CV |
| common test statistics | (F, t, $\chi^2$, etc.) |
| confidence interval | CI |
| correlation coefficient (multiple) | R |
| correlation coefficient (simple) | r |
| covariance | cov |
| degree (angular ) | ° |
| degrees of freedom | df |
| expected value | *E* |
| greater than | > |
| greater than or equal to | ≥ |
| harvest per unit effort | HPUE |
| less than | < |
| less than or equal to | ≤ |
| logarithm (natural) | ln |
| logarithm (base 10) | log |
| logarithm (specify base) | $log_{2,}$ etc. |
| minute (angular) | ' |
| not significant | NS |
| null hypothesis | $H_O$ |
| percent | % |
| probability | P |
| probability of a type I error (rejection of the null hypothesis when true) | α |
| probability of a type II error (acceptance of the null hypothesis when false) | β |
| second (angular) | " |
| standard deviation | SD |
| standard error | SE |
| variance | |
| population | Var |
| sample | var |

# *FISHERY DATA SERIES NO. 15-43*

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by

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# ABSTRACT

Dual-frequency identification sonar (DIDSON) was used to estimate adult summer chum salmon *Oncorhynchus keta* and pink salmon *Oncorhynchus gorbuscha* passage in the Anvik River from June 17 to July 26, 2014. Apportionment to species was determined from data collected from tower counts. A total of 399,796 summer chum and 973,254 pink salmon were estimated to have passed the sonar site. A beach seine sample fishery was conducted to collect age, sex, and length information. Timing of the 2014 summer chum salmon run was 2 days early at the first quartile and 3 days early at the third quartile compared to the average historic run timing based on 1979–1984 and 1987–2013 runs. Female summer chum salmon accounted for 54.6% of the entire summer chum salmon run. Age-0.3 summer chum salmon made up an estimated 44.8% of the passage; age 0.4 accounted for 48.3%. Both sonar systems functioned well with minimal interruptions to operation. Range of ensonification was considered adequate for most fish that migrated upstream.

Key words: chum salmon *Oncorhynchus keta*, pink salmon *O. gorbuscha*, sonar, dual-frequency identification sonar DIDSON, escapement, Anvik River.

# INTRODUCTION

The purpose of the Anvik River sonar project is to monitor escapement of adult summer chum *Oncorhynchus keta* and pink salmon *O. gorbuscha* to the Anvik River drainage, believed to be the largest producer of summer chum salmon in the Yukon River drainage (Bergstrom et al. 1999). Additional major spawning populations of summer chum salmon occur in the following tributaries of the Yukon River: the Andreafsky River, Rodo River, Nulato River, Melozitna River, and Tozitna River. Spawning tributaries in the Koyukuk River drainage are the Gisasa River and Hogatza River and in tributaries to the Tanana River drainage, which include the Chena River and the Salcha River (Figure 1). Chinook salmon *O. tshawytscha* and pink salmon spawn in the Anvik River concurrently with summer chum salmon. Fall chum are a later run of chum salmon (Estensen et al. 2013), and coho salmon *O. kisutch* have been reported to spawn in the Anvik River drainage during the fall.

Timely and accurate reporting of summer chum escapement from the Anvik River sonar project helps Yukon River Alaska Department of Fish and Game (ADF&G) fishery managers ensure the Anvik River biological escapement goal (BEG) of 350,000 to 700,000 summer chum salmon is met (ADF&G 2004). This assessment is necessary to determine if summer chum salmon abundance will meet downstream subsistence and commercial harvest, as well as upstream escapement needs. Subsistence and commercial fishery openings and closures may be based, in part, upon this assessment.

High abundance of pink salmon occurs on even years in the Yukon River drainage (Estensen et al. 2013). Apportionment of pink salmon passage on the Anvik River during even years is necessary to accurately access summer chum escapement from the total sonar passage estimate.

From 1972 to 1979, Anvik River summer chum and pink salmon escapements were partially estimated from visual counts made at counting towers above the confluence of the Anvik and Yellow rivers, (Figure 2). A site 9 km above the Yellow River, on the mainstem Anvik River, was used from 1972 to 1975 (Lebida[1]; Trasky 1974, 1976; Mauney 1977). From 1976 to 1979, a site on the mainstem Anvik River, near the confluence of Robinhood Creek and the Anvik River, was used (Mauney 1979, 1980; Mauney and Geiger 1977). Since 1979, the Anvik River sonar project has been located approximately 76 km upstream of the confluence of the Anvik and Yukon rivers, 5 km below Theodore Creek at lat 62°44.208′N, long 160°40.724′W. The land is

[1] Lebida, R. C. Unpublished. Yukon River anadromous fish investigations, 1973. Alaska Department of Fish and Game, Juneau.

public, managed by the Bureau of Land Management (BLM), and leased to ADF&G for public purposes until 2023. Aerial survey data indicate summer chum salmon spawn primarily upstream of this sonar site.

Side-scanning sonar, capable of detecting migrating salmon along the banks, was first used at the current Anvik River sonar site in 1979 to determine the feasibility of using sonar to enumerate summer chum passage (Sandone 1993). Bendix sonar equipment was used for escapement estimates from 1980 to 2003. In 2003, a side-by-side comparison was done with Hydroacoustic Technology Incorporated (HTI)[2] split-beam sonar equipment where it was found that the Bendix and HTI produced similar abundance estimates (Dunbar and Pfisterer 2007). In 2004, the change was made to HTI sonar equipment. In 2006, a side-by-side comparison was done between HTI and a dual-frequency identification sonar (DIDSON; Belcher et al. 2002). High water for most of the season prevented normal operation of the split-beam sonar, but it was found the DIDSON abundance estimate was 61% higher than the split-beam abundance estimate (McEwen 2007). DIDSON has been used in the Yukon and Kenai rivers (Lozori 2015; Miller et al. 2014) to generate daily passage estimates where bottom profiles are appropriate for the wider beam angle and shorter range capabilities of this sonar. In 2007 the change was made to DIDSON sonar.

The Anvik River sonar project provides timely and accurate information to Yukon River fishery managers. DIDSON is used to collect salmon passage data and tower estimates are used to apportion the counts to chum or pink salmon. Beach seines are used to collect age, sex, and length (ASL) data. HOBO temperature loggers are used to monitor hydrologic parameters daily. This report presents data collected in 2014 and compares the results to previous years.

# OBJECTIVES

The goal of this project in 2014 was to provide daily inseason estimates of adult summer chum and pink salmon escapement into the Anvik River to fishery managers. Primary objectives included the following:

1. Estimate summer chum and pink salmon abundance in the Anvik River using DIDSON and tower counts for apportionment, and determine if the summer chum salmon BEG is met from approximately June 16 through July 26.
2. Operate DIDSON such that 95% of migrating salmon are detected within three-quarters of the ensonified range on both banks.

Secondary objectives included the following:

3. Collect a minimum of 162 summer chum salmon samples during each of 4 temporal strata (corresponding to passage quartiles) throughout the season using a beach seine to estimate the ASL composition of the Anvik River summer chum salmon passage, such that simultaneous 95% confidence intervals of age composition in each sample are no wider than 0.20 ($\alpha$ = 0.05 and $d$ = 0.10).
4. Collect daily climatic and hydrologic measurements representative of the study area.

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[2] Product names used in this report are included for scientific completeness but do not constitute a product endorsement.

# METHODS

## STUDY AREA

The Anvik River originates at an elevation of 400 m and flows in a southerly direction approximately 230 km to its mouth at river kilometer mile (rkm) 512 of the Yukon River (Figure 1). This narrow runoff stream has a substrate of mainly gravel and cobble. Bedrock is exposed in some of the upper reaches. The Yellow River (Figure 2) is a major tributary of the Anvik drainage and is located approximately 100 km upstream from the mouth of the Anvik River. Downstream from the confluence of the Yellow River, the Anvik River changes from a moderate-gradient system to a low-gradient system meandering through a much broader flood plain. Turbid waters from the Yellow River greatly reduce water clarity of the Anvik River below their confluence. Numerous oxbows, old channel cutoffs, and sloughs are found throughout the lower Anvik River.

At the sonar site, the Anvik River is characterized by broad meanders, with large gravel bars on inside bends and cut banks with exposed soil, tree roots, and snags on outside bends. As with past years, we were able to use the same location, due to the site's stability. The river substrate at the sonar site is fine, smooth gravel, sand, and silt. The right bank slopes gradually to the thalweg approximately 66 m from shore, and the left bank slopes steeply to the thalweg approximately 12 m from shore depending on water level (Figure 3).

## HYDROACOUSTIC EQUIPMENT

Two Sound Metrics Corporation DIDSONs were deployed at the Anvik River sonar site: a long-range DIDSON operating at frequency of 1.2 MHz (high frequency option using 48 beams) on the right bank, and a standard DIDSON operating at frequency of 1.8 MHz (high frequency option using 96 beams) on the left bank (Table 1). Because of the shallow nature of the right bank bottom profile, a concentrator lens (approximately 2°) was used to lessen interference from surface and bottom reverberation. A laptop computer running DIDSON software controlled each unit, and an external hard drive was used to store data. A wireless Ethernet router transferred data from the left bank to the controlling laptop on the right bank (Figure 4).

## SONAR DEPLOYMENT AND OPERATION

Prior to transducer deployment, river bottom profiles were checked to ensure the sites were acceptable for ensonification. Range and depth data was collected from transects made from bank-to-bank using a boat-mounted Lowrance dual-frequency transducer (down-looking sonar) with a built-in Global Positioning System (GPS). A bottom profile was then generated using the data points plotted with Microsoft® Excel (Figure 3).

Both banks were ensonified on July 17, and operations ran continuously through July 26. The DIDSONs were mounted on aluminum frames and aimed using manual crank-style rotators (Figure 5). The DIDSONs were placed offshore in a fixed location with the beams directed perpendicular to current flow, approximately 25 m from the right bank and approximately 3 m from the left bank (Figure 3). Operators adjusted the pan and tilt by viewing the video-like acoustic image and relaying aiming instructions to a technician via handheld VHF radio. The wide axis of each beam was oriented horizontally and positioned close to the river bottom to maximize residence time of targets in the beam. On the right bank, the river was ensonified approximately 20 m from the DIDSON, and on the left bank the river was ensonified approximately 10 m from the DIDSON. Approximately 55% of the river was ensonified depending on water level. Daily visual inspections of the sonar pods and images confirmed proper placement and orientation of the DIDSONs, and alerted operators as to when they needed to be repositioned to accommodate changing water levels.

Partial weirs were erected perpendicular to the current and extended from the shore out 1 to 3 m beyond each DIDSON (Figures 3 and 6). The weirs diverted migrating adult salmon offshore and in front of the DIDSONs to provide sufficient offshore distance for fish to be detected in the sonar beam, but allowing passage of small, resident, non-target species (Arctic grayling *Thymallus arcticus*, northern pike *Esox lucius*, longnose sucker *Catostomus catostomus*, and whitefish *Coregonus* spp.).

## SONAR DATA PROCESSING AND PASSAGE ESTIMATION

Acoustic sampling was conducted on both banks starting at the top of each hour for 30 min, 24 h per day, and 7 days per week, except for short periods when the generator was serviced or adjustments were made to the sonars. Operators opened each 30 min data file in an echogram viewer program (Echotastic, developed by ADF&G staff), and marked each upstream fish track with a computer mouse. All fish were counted manually except for small fish (<400 mm), which were assumed not to be salmon. Fish length measurements were made manually using DIDSON software marking tools. Upstream direction of travel was verified using the Echotastic video feature which displayed the raw acoustic fish images. The 30 min counts were saved as text files and manually recorded on a data form. The count data was then entered into an Excel spreadsheet to calculate daily passage.

Daily fish passage ( $\hat{y}_{dz}$ ) on day ($d$) and bank ($z$) was estimated by first calculating the hourly passage rate ( $\hat{y}_{dzp}$) for each period ($p$):

$$\hat{y}_{dzp} = x_{dzp}\left(60/m_{dzp}\right), \tag{1}$$

where the rate is calculated by expanding the count $x_{dzp}$ by the inverse of the fraction of the hour sampled, where $m_{dzp}$ is the minutes counted. Normally this is equivalent to doubling the 30 min count (i.e., 60 / 30 = 2). The daily passage for each bank is estimated by summing the 24 hourly samples:

$$\hat{y}_{dz} = \sum_{p=1}^{24} \hat{y}_{dzp} \,. \tag{2}$$

Finally, the total daily passage $\hat{y}_d$ is estimated by adding the daily passage for the 2 banks:

$$\hat{y}_d = \sum_{z} \hat{y}_{dz} \,. \tag{3}$$

Sonar sampling periods were spaced at regular (systematic) intervals. Treating the systematically-sampled sonar counts as a simple random sample may overestimate the variance of the total because sonar counts can be highly autocorrelated (Wolter 1985). To accommodate these data characteristics, a variance estimator based on the squared differences of successive observations was utilized. This estimator was adapted from the estimator used at the Yukon River sonar project (Pfisterer 2002). The variance for the passage estimate for bank ($z$) on day ($d$) was estimated as

$$\hat{V}ar_{y_{dz}} = 24^2 \cdot \frac{1 - f_{dz}}{n_{dz}} \cdot \frac{\sum_{p=24}^{n_{dz}} \left(y_{dzp} - y_{dz,p-1}\right)^2}{2 n_{dz}\left(n_{dz} - 1\right)}, \tag{4}$$

where $n_{dz}$ is the number of periods sampled in the day (generally 24) and $f_{dz}$ is the fraction of the day sampled (12 / 24 = 0.5). Finally, because the passage estimates are assumed independent between zones and among days, the total variance was estimated as the sum of the variances:

$$\hat{V}ar\left(\hat{y}\right) = \sum_d \sum_z \hat{V}ar\left(\hat{y}_{dz}\right). \tag{5}$$

## MISSING DATA

Depending on the amount of time that was missed, different methods were used to make up for incomplete or missing counts. If less than 25 min were missed the passage rate for the period within that interval was used to estimate passage for the non-sampled portion of the interval as in Equation 1.

If data from 1 or more complete samples were missing, counts were interpolated by averaging counts from samples before and after the missing sample(s) as follows:

$$\hat{y}_s = \left(1/n \sum_{i=1}^{n} x_i\right) \left\{ \begin{array}{l} s = 1, n = 4 \\ s = 2, n = 6 \\ s = 3, n = 8 \\ s = 4, n = 10 \end{array} \right\}. \tag{6}$$

Where $s$ is the number of missed samples, $n$ is the number of samples used for interpolation (half before and half after the missing sample(s)), and $x_i$ is the count for each sample $i$.

If more than 4 samples were missed, an XY scatterplot with a regression line was plotted using the known fish counts for the day from both left bank and right bank. The linear regression equation of the line was then used to calculate missing fish counts for each missing sample ($s$):

$$\hat{y}_S = a + bx_S. \tag{7}$$

Where $a$ and $b$ are the regression coefficients, $x$ equals the count for sample ($s$) on the opposite bank, and $\hat{y}_S$ is the estimated passage for missing sample ($s$).

## SPECIES APPORTIONMENT

Tower counts were conducted 4 times per day (0730, 1300, 1700, and 2000) for 15 min on each bank to apportion the sonar estimates to summer chum and pink salmon migrating past the sonar site. On the right bank, a 4.5 m tower was anchored in the river just downstream of the sonar at the end of the weir. On the left bank, a tower was erected on shore just upriver of the sonar (Figure 6). Technicians stood on top of the towers with polarized sunglasses and counted salmon by species passing the sonar. Since 2009, white fabric flash panels, similar to panels used at the Chena River Chinook salmon escapement project (Savereide and Huang 2014), have been deployed across the river bottom to help with visual identification of salmon species during tower counts (McEwen 2010). The number of salmon species for each bank and the visible range were entered into an Excel spreadsheet; non-salmon species were not counted or recorded.

Daily sonar passage estimates ($y$) by species ($a$) were apportioned to either pink or summer chum salmon by applying the estimated proportion ($p$) to the unadjusted daily passage estimate for each bank ($z$):

$$\hat{y}_{dza} = \hat{y}_{dz} \cdot \hat{p}_{dza} . \tag{8}$$

With only 2 species apportioned for, the variance of the proportion follows the binomial distribution

$$Var\left(\hat{p}_{dza}\right) = \hat{p}_{dza} \cdot \left(1 - \hat{p}_{dza}\right)/(n-1) , \tag{9}$$

and the variance of the species passage estimate was calculated as

$$\hat{V}ar\left(\hat{y}_{dza}\right) = \hat{y}_{dz}^{2} \cdot \hat{V}ar\left(\hat{p}_{dza}\right) + \hat{p}_{dza}^{2} \cdot \hat{V}ar\left(\hat{y}_{dz}\right) - \hat{V}ar\left(\hat{y}_{dz}\right) \cdot \hat{V}ar\left(\hat{p}_{dza}\right) . \tag{10}$$

Total daily passage by species was estimated by summing both banks

$$\hat{y}_{da} = \sum_{z} \hat{y}_{dza} , \tag{11}$$

and passage estimates were summed over both banks and all days to obtain a seasonal estimate for species ($y_a$):

$$\hat{y}_{a} = \sum_{d} \sum_{z} \hat{y}_{dza} . \tag{12}$$

Finally, passage estimates were assumed independent between banks and among days, so the variance of their sum was estimated by the sum of their variances:

$$\hat{V}ar\left(\hat{y}_a\right) = \sum_d \sum_z \hat{V}ar\left(\hat{y}_{dza}\right), \tag{13}$$

and, assuming normally distributed errors, 90% confidence intervals were calculated as

$$\hat{y}_a \pm 1.645\sqrt{\hat{V}ar(\hat{y}_a)}. \tag{14}$$

## AGE, SEX, AND LENGTH SAMPLING

Temporal strata, used to characterize the age and sex composition of the summer chum salmon escapement, were defined as dates when 25%, 50%, 75%, and 100% of the total run had passed the sonar site. To determine inseason ASL sampling dates, historical mean quartile ASL dates were used (Table 2). The strata represent an attempt to sample the escapement for ASL information in proportion to the total run.

To meet regionwide standards for the sample size needed to describe a salmon population, the initial seasonal ASL sample goal was 648 summer chum salmon, with a minimum of 162 summer chum salmon samples collected using beach seines during each temporal stratum (Bromaghin 1993). Sample size goals are based on a 95% confidence with an accuracy (*d*) and precision ($\alpha$) objectives of $d = 0.10$ and $\alpha = 0.05$, assuming 2 major age classes and 2 minor age classes with a scale rejection rate of 15%. The beach seining goal for Chinook salmon was also developed to sample all fish captured while pursuing the summer chum salmon sampling goal.

A beach seine (31 m long, 66 meshes deep, 2.5 in mesh) was drifted, beginning approximately 10 m downstream of the sonar site, to capture summer chum salmon and collect ASL data. All resident freshwater fish captured were tallied by species and released. Pink salmon were counted by sex based on external characteristics, and released. Summer chum salmon were placed in a mobile holding pen deployed in the river and each were noted for sex, measured to the nearest 1 mm from mideye to tail fork, and 1 scale was taken for age determination. Scales were collected from an area posterior to the base of the dorsal fin and above the lateral line on the left side of the fish (Clutter and Whitesel 1956). The adipose fin was clipped on each sampled summer chum salmon to prevent resampling. Chinook salmon were sampled using the same methods as for summer chum salmon, except 3 scale samples were taken from each fish.

## CLIMATE AND HYDROLOGIC OBSERVATIONS

Climatic and hydrologic data were collected at approximately 1800 hours each day at the sonar site. River depth was monitored using a staff gauge marked in 1 cm increments. Change in water depth was presented as negative or positive increments from the initial reading of 0.0 cm. Water temperature was measured using a HOBO water temp logger, which electronically recorded the temperature every hour on the hour for the duration of the project. Subjective notes on wind speed and direction, cloud cover, and precipitation were also recorded.

# RESULTS

## SUMMER CHUM AND PINK SALMON ESTIMATION

The total summer chum salmon passage estimate at the Anvik River sonar site was 399,796 from June 17 to July 26, 2014. The first quarter point fell on July 1, the midpoint on July 5, and third quarter point on July 10. A peak daily passage estimate of 34,497 summer chum salmon occurred on July 1 and 1,635 fish passed on July 26, the last day of sonar operation (Table 3). When compared to average historic run timing based on 1979–1984 and 1987–2013 runs, summer chum salmon passage dates were 2 days early at the first quartile and 3 days early at the third quartile (Table 2).

The central half of the summer chum salmon run passed between July 1 and July 10, the duration of 9 days is the same as in 2012 and 2013, but less than the historic mean of 10 days (Table 2). Daily passage between the first and third quartile dates ranged from 34,497 (July 1) to 15,657 (July 10), with an estimated total of 204,806 summer chum salmon passing by the sonar site during this time (Table 3). The 2014 summer chum salmon escapement estimate of 399,796 was less than the average Anvik River escapement estimate of 587,525 fish (Table 2). The 2014 escapement was within the BEG of 350,000 to 700,000 summer chum salmon.

The timing of the summer chum salmon run into the Anvik River was roughly similar to the pattern observed at the lower Yukon River sonar project near the village of Pilot Station (Figure 7). Approximately 21% of the summer chum salmon that were estimated to have passed Pilot Station (1,924,425) were observed at the Anvik River sonar project; this is below the overall 1995 to 2013 contribution of 33.5% (McEwen 2015). Historically the percentage of Yukon River summer chum salmon bound for the Anvik River has fluctuated and can be broken into 2 distinct periods. During the period from 1995 to 2002 the average contribution was 49.6%. From 2003 to 2013, the average contribution was 23.2%, which is slightly greater than observed in 2014.

The total pink salmon passage estimate was 973,254 from June 26 to July 26, 2014. The first quarter point fell on July 4, the midpoint on July 16, and third quarter point on July 21 (Table 4). A peak daily passage estimate of 74,932 pink salmon occurred on July 14 and 27,859 fish passed on July 26, the last day of sonar operation. Based on 1994, 2000–2004, and 2008–2013 run timing estimates, pink salmon passage dates 8 days early on the first quartile and 1 day late at the third quartile (Table 5). The 2014 pink salmon escapement estimate was above the average Anvik River escapement of 280,698 and was the highest recorded escapement between 1994 and 2012.

Total sonar passage estimates include expansions for sampling time missed. On the left bank, 810 min were missed, which accounted for an additional 27,159 fish or 7.2% of the total left bank estimate. On the right bank, 330 min were missed, which accounted for an additional 12,441 fish or 1.2% of the total right bank estimate (Table 6). Most of the estimates for missing counts were due to high water knocking the weir panels over making it necessary to re-aim the sonar.

The objective of estimating summer chum and pink salmon abundance in the Anvik River using DIDSON from approximately June 16 through July 26 was met.

## SPATIAL AND TEMPORAL DISTRIBUTION

Fish were shore oriented on both banks (Figure 8). On the left bank, approximately 95% of the fish were detected within 7 m of the transducer, and 99% within 9 m. On the right bank, 95% of the fish were detected within 9 m of the transducer, and 99% within 14 m. The objective is to operate imaging sonar such that 95% of the migrating salmon are detected within three quarters of the ensonified area on both banks and it was met. Approximately 74% of the total fish passage occurred on the right bank, which is consistent with historical migration trends at the project with the exception of 3 years: 1992 (43%), 1996 (45%), and 1997 (39%) (Sandone 1994; Fair 1997; Chapell 2001).

Overall, when considering both banks combined, there was a diurnal pattern of fish passage on the Anvik River this season, with the lowest passage occurring at 1100 (Figure 9). High passage tended to alternate between banks with the passage decreasing on the right bank throughout the day.

## SPECIES APPORTIONMENT

Summer chum and pink salmon were the most prominent species observed on both banks during tower counts. Counts began on June 20, and the first pink salmon were observed on both banks on June 26. Proportionally, summer chum salmon accounted for 13% of the total tower count on the left bank and 42% on the right bank (Table 7).

## SUMMER CHUM AGE AND SEX COMPOSITION

The objective of collecting 162 summer chum salmon scale samples in each of 4 temporal strata was not met this season because of mechanical problems with outboard motors, which limited fishing time. From June 27 through July 14, a total of 253 ASL samples were obtained, and from these samples, 152 scales were analyzed as ageable post season. Because of the low total sample size, only 3 strata were defined in 2014: June 17–June 30, July 1–July 5, and July 9–July 15 (Table 8).

Scale sample analysis indicated that there were 2 major age classes, age 0.3 (44.8%) and age 0.4 (48.3%), as well as 1 minor class, age 0.5 (6.9%). The age composition observed at the Anvik River sonar project was similar to the rest of the Yukon River drainage with ages-0.3 and -0.4 summer chum salmon being the dominant age groups throughout the Yukon River drainage (Tables 8 and Figure 10).

Average productivity (return per spawner) on the Anvik River for the last complete 5 years (2004–2008) was 1.2 (Table 9). Anvik River summer chum salmon return per spawner has ranged from a low of 0.17 for the 1995 brood year to a high of 5.57 for the 2001 brood year. The average over the 20-year period 1989 to 2008 is 1.4.

Age and sex composition of summer chum salmon passing the sonar site changes through the duration of the run. Usually, the trend is an increasing proportion of younger salmon and a higher proportion of female salmon as the run progresses (Fair 1997); the 2014 run was consistent with this pattern (Table 8). Female summer chum accounted for 54.6% of the entire run, which is close to the 1972–2013 average of 55.9% (Figure 11).

## HYDROLOGIC AND CLIMATOLOGICAL CONDITIONS

The objective of monitoring hydrological parameters daily at the project site was met in 2014. The water level remained fairly low throughout the season, with the lowest level recorded on July 3–July 10 (Figure 12). Except for 1 major increase on July 21, the water level remained near or below the zero datum mark. Overall, between June 18 and July 26 minimum and maximum water level differed by 22 cm. Water temperatures at the project ranged from 8.4°C on June 17 to 18.6°C on July 6 (Figure 13). Air temperature data are not available for 2014.

# DISCUSSION

Though data processing procedures have worked adequately for estimating salmon passage at the site, changes in methods are anticipated next season. Currently, passage estimates are calculated by hand, entering DIDSON counts and minutes sampled into an Excel spreadsheet. Computation in the spreadsheet expands DIDSON counts for the full hour, adjusts counts for missing samples from both banks, and calculates the daily passage by summing the hourly passage rates. During the 2015 field season, we intend to eliminate the use of Excel and calculate passage estimates using an R script. The script will simplify passage estimation by eliminating several calculations for missing data, as well as eliminate transcription error from potential data entry mistakes. Additionally, the R script output will provide diagnostic tables and charts, which will present daily information pertaining to hourly passage, fish distribution, and daily passage estimates by bank. The output information will provide useful inseason analysis of fish passage and help evaluate the accuracy of the sonar estimates.

Although, based on passage distribution (Figure 8), we do not feel there is significant salmon passage beyond 10 m on the left bank, next season we intend to increase the range on the left bank to 20 m. Little is known about spatial distribution caused by interactions between high abundance of pink and summer chum salmon migrating past the sonar site. Because of increased pink salmon escapement into the Anvik River the last few years, we intend to evaluate if there are any shifts in distribution during concurrent periods of high pink and chum salmon passage. Collection of data in 2015 will provide baseline information to evaluate what proportion of chum passage does occur beyond 10 m (if any) and may prove useful in comparison when data are collected during years of high pink salmon abundance.

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# TABLES AND FIGURES

Table 1.–Technical specifications for dual-frequency identification sonars (DIDSON) at the Anvik River sonar site, 2014.

| Setting | Bank | Value |
|---|---|---|
| Mode | Right | High Frequency |
| | Left | High Frequency |
| Frequency (MHz) | Right | 1.20 |
| | Left | 1.80 |
| Number of beams | Right | 48 |
| | Left | 96 |
| Window length (m) | Right | 20 m |
| | Left | 10 m |
| Vertical beam width | Right | 2° |
| | Left | 14° |
| Start range (m) | Both | 0.83 |
| Frame rate | Both | 6 frames/s |
| Duration in minutes | Both | 30 |
| Field of view | Both | 29° |

Table 2.–Annual passage estimates and passage timing for summer chum salmon runs, at the Anvik River sonar, 1979–2014.

| | | | | | | Days between | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year[a] | Sonar passage estimate | First count | First quartile | Median | Third quartile | First count & first quartile | First quartile & median | Median & third quartile | First & third quartile |
| 1979 | 277,712 | 6/23 | 7/2 | 7/8 | 7/12 | 9 | 6 | 4 | 10 |
| 1980 | 482,181 | 6/28 | 7/6 | 7/11 | 7/16 | 8 | 5 | 5 | 10 |
| 1981 | 1,479,582 | 6/20 | 6/27 | 7/2 | 7/7 | 7 | 5 | 5 | 10 |
| 1982 | 444,581 | 6/25 | 7/7 | 7/11 | 7/14 | 12 | 4 | 3 | 7 |
| 1983 | 362,912 | 6/21 | 6/30 | 7/7 | 7/12 | 9 | 7 | 5 | 12 |
| 1984 | 891,028 | 6/22 | 7/5 | 7/9 | 7/13 | 13 | 4 | 4 | 8 |
| 1985 | 1,080,243 | 7/5 | 7/10 | 7/13 | 7/16 | 5 | 3 | 3 | 6 |
| 1986 | 1,085,750 | 6/21 | 6/29 | 7/2 | 7/6 | 8 | 3 | 4 | 7 |
| 1987 | 455,876 | 6/21 | 7/5 | 7/12 | 7/16 | 14 | 7 | 4 | 11 |
| 1988 | 1,125,449 | 6/21 | 6/30 | 7/3 | 7/9 | 9 | 3 | 6 | 9 |
| 1989 | 636,906 | 6/20 | 7/1 | 7/7 | 7/13 | 11 | 6 | 6 | 12 |
| 1990 | 403,627 | 6/22 | 7/2 | 7/7 | 7/15 | 10 | 5 | 8 | 13 |
| 1991 | 847,772 | 6/21 | 7/1 | 7/10 | 7/16 | 10 | 9 | 6 | 15 |
| 1992 | 775,626 | 6/29 | 7/5 | 7/8 | 7/12 | 6 | 3 | 4 | 7 |
| 1993 | 517,409 | 6/19 | 7/5 | 7/12 | 7/18 | 16 | 7 | 6 | 13 |
| 1994 | 1,124,689 | 6/19 | 7/1 | 7/7 | 7/11 | 12 | 6 | 4 | 10 |
| 1995 | 1,339,418 | 6/19 | 7/1 | 7/6 | 7/11 | 12 | 5 | 5 | 10 |
| 1996 | 933,240 | 6/18 | 6/25 | 7/1 | 7/6 | 7 | 6 | 5 | 11 |
| 1997 | 605,752 | 6/19 | 6/28 | 7/3 | 7/10 | 9 | 5 | 7 | 12 |
| 1998 | 487,301 | 6/22 | 7/5 | 7/10 | 7/14 | 13 | 5 | 4 | 9 |
| 1999 | 437,356 | 6/27 | 7/6 | 7/10 | 7/16 | 9 | 4 | 6 | 10 |
| 2000 | 196,349 | 6/21 | 7/8 | 7/11 | 7/13 | 17 | 3 | 2 | 5 |
| 2001 | 224,058 | 6/26 | 7/6 | 7/10 | 7/15 | 10 | 4 | 5 | 9 |
| 2002 | 459,058 | 6/22 | 7/3 | 7/7 | 7/12 | 11 | 4 | 5 | 9 |
| 2003 | 256,920 | 6/21 | 7/5 | 7/10 | 7/15 | 14 | 5 | 5 | 10 |
| 2004 | 365,353 | 6/22 | 6/29 | 7/5 | 7/9 | 7 | 6 | 4 | 10 |
| 2005 | 525,391 | 6/26 | 7/4 | 7/10 | 7/15 | 8 | 6 | 5 | 11 |
| 2006 | 605,485 | 6/28 | 7/3 | 7/6 | 7/12 | 5 | 3 | 6 | 9 |
| 2007 | 460,121 | 6/26 | 7/5 | 7/10 | 7/17 | 9 | 5 | 7 | 12 |

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Table 2.–Page 2 of 2.

| Year | Sonar passage estimate | First count | First quartile | Median | Third quartile | Days between: First count & first quartile | Days between: First quartile & median | Days between: Median & third quartile | Days between: First & third quartile |
|---|---|---|---|---|---|---|---|---|---|
| 2008 | 374,928 | 6/18 | 7/5 | 7/8 | 7/16 | 17 | 3 | 8 | 11 |
| 2009 | 191,566 | 6/18 | 7/4 | 7/9 | 7/15 | 16 | 5 | 6 | 11 |
| 2010 | 396,173 | 6/16 | 7/8 | 7/12 | 7/18 | 22 | 4 | 6 | 10 |
| 2011 | 642,527 | 6/16 | 7/2 | 7/7 | 7/14 | 16 | 5 | 7 | 12 |
| 2012 | 484,090 | 6/18 | 7/9 | 7/14 | 7/18 | 21 | 5 | 4 | 9 |
| 2013 | 577,877 | 6/17 | 7/2 | 7/8 | 7/11 | 15 | 6 | 3 | 9 |
| 2014 | 399,795 | 6/17 | 7/1 | 7/5 | 7/10 | 14 | 4 | 5 | 9 |
| Average | 587,525 | 6/21 | 7/3 | 7/8 | 7/13 | 12 | 5 | 5 | 10 |
| Median | 484,090 | 6/21 | 7/4 | 7/8 | 7/14 | 11 | 5 | 5 | 10 |
| SD | 314,126 | 3.5 | 3.2 | 3.0 | 3.0 | 4.1 | 1.4 | 1.4 | 1.9 |

[a] The mean, median and standard deviation of the timing statistics includes estimates from years 1979–1984 and 1987–2013. In 1985 sonar counting operations began late and in 1986, sonar counting operations were terminated early, probably resulting in the incorrect calculation of the quartile statistics. Therefore, the 1985 and 1986 run timing statistics were excluded from the calculation of the overall mean and timing statistic and associated standard deviation (SD).

Table 3.–Summer chum salmon daily and cumulative counts, Anvik River sonar, 2014.

| Date | Left bank | Right bank | Daily total | Cumulative Count | Cumulative Proportion |
|---|---|---|---|---|---|
| 6/17 | 224 | 96 | 320 | 320 | 0.001 |
| 6/18 | 215 | 1026 | 1,241 | 1,561 | 0.004 |
| 6/19 | 606 | 1,643 | 2,249 | 3,810 | 0.010 |
| 6/20 | 1,766 | 3,378 | 5,144 | 8,954 | 0.022 |
| 6/21 | 1,882 | 3,892 | 5,774 | 14,728 | 0.037 |
| 6/22 | 2,060 | 9,188 | 11,248 | 25,976 | 0.065 |
| 6/23 | 672 | 1,604 | 2,276 | 28,252 | 0.071 |
| 6/24 | 1,106 | 5,092 | 6,198 | 34,450 | 0.086 |
| 6/25 | 1,222 | 5,912 | 7,134 | 41,584 | 0.104 |
| 6/26 | 1,175 | 10,587 | 11,762 | 53,346 | 0.133 |
| 6/27 | 1,400.0 | 5,979.1 | 7,379 | 60,725 | 0.152 |
| 6/28 | 2,035 | 9,297 | 11,332 | 72,057 | 0.180 |
| 6/29 | 2,065 | 7,277 | 9,342 | 81,399 | 0.204 |
| 6/30 | 2,703 | 13,340 | 16,043 | 97,442 | 0.244 |
| 7/01 [a] | 4,156 | 30,340 | 34,497 | 131,939 | 0.330 |
| 7/02 | 1,685 | 11,633 | 13,318 | 145,257 | 0.363 |
| 7/03 | 1,749 | 14,438 | 16,187 | 161,444 | 0.404 |
| 7/04 | 3,617 | 27,890 | 31,506 | 192,950 | 0.483 |
| 7/05 [b] | 1,719 | 19,976 | 21,695 | 214,645 | 0.537 |
| 7/06 | 3,204 | 23,050 | 26,254 | 240,899 | 0.603 |
| 7/07 | 1,520 | 18,235 | 19,755 | 260,654 | 0.652 |
| 7/08 | 992 | 9,360 | 10,352 | 271,006 | 0.678 |
| 7/09 | 2,041 | 13,544 | 15,585 | 286,591 | 0.717 |
| 7/10 [c] | 2,328 | 13,329 | 15,657 | 302,248 | 0.756 |
| 7/11 | 1,284 | 15,129 | 16,414 | 318,662 | 0.797 |
| 7/12 | 8,477 | 5,081 | 13,558 | 332,220 | 0.831 |
| 7/13 | 2,109 | 9,891 | 12,000 | 344,220 | 0.861 |
| 7/14 | 878 | 8,977 | 9,855 | 354,075 | 0.886 |
| 7/15 | 1,369 | 5,443 | 6,811 | 360,886 | 0.903 |
| 7/16 | 726 | 8,790 | 9,516 | 370,402 | 0.926 |
| 7/17 | 684 | 5,399 | 6,083 | 376,485 | 0.942 |
| 7/18 | 597 | 3,469 | 4,066 | 380,551 | 0.952 |
| 7/19 | 557 | 2,660 | 3,217 | 383,768 | 0.960 |
| 7/20 | 156 | 1,563 | 1,719 | 385,487 | 0.964 |
| 7/21 | 236 | 2,596 | 2,832 | 388,319 | 0.971 |
| 7/22 | 336 | 2,869 | 3,205 | 391,524 | 0.979 |
| 7/23 | 949 | 854 | 1,803 | 393,327 | 0.984 |
| 7/24 | 240 | 2,091 | 2,331 | 395,658 | 0.990 |
| 7/25 | 214 | 2,289 | 2,503 | 398,161 | 0.996 |
| 7/26 | 241 | 1,394 | 1,635 | 399,796 | 1.000 |
| Total | 61,196 | 338,599 | 399,796 | 399,796 | |

*Note*: The large box indicates the central 50% of the summer chum salmon run (second and third quartiles).

[a] First quarter point.

[b] Midpoint.

[c] Third quarter point.

Table 4.–Pink salmon daily and cumulative counts, Anvik River sonar, 2014.

| Date | Left bank | Right bank | Daily total | Cumulative Count | Cumulative Proportion |
|---|---|---|---|---|---|
| 6/17 | 0 | 0 | 0 | 0 | 0.000 |
| 6/18 | 0 | 0 | 0 | 0 | 0.000 |
| 6/19 | 0 | 0 | 0 | 0 | 0.000 |
| 6/20 [a] | 0 | 0 | 0 | 0 | 0.000 |
| 6/21 | 0 | 0 | 0 | 0 | 0.000 |
| 6/22 | 0 | 0 | 0 | 0 | 0.000 |
| 6/23 | 0 | 0 | 0 | 0 | 0.000 |
| 6/24 | 0 | 0 | 0 | 0 | 0.000 |
| 6/25 | 0 | 0 | 0 | 0 | 0.000 |
| 6/26 | 147 | 315 | 462 | 462 | 0.000 |
| 6/27 | 0 | 429 | 429 | 891 | 0.001 |
| 6/28 | 33 | 557 | 590 | 1,481 | 0.002 |
| 6/29 | 71 | 1,383 | 1,454 | 2,935 | 0.003 |
| 6/30 | 169 | 1,532 | 1,701 | 4,636 | 0.005 |
| 7/01 | 520 | 3,380 | 3,899 | 8,535 | 0.009 |
| 7/02 | 421 | 1,899 | 2,320 | 10,856 | 0.011 |
| 7/03 | 1,421 | 4,404 | 5,825 | 16,681 | 0.017 |
| 7/04 [b] | 2,583 | 9,696 | 12,279 | 28,961 | 0.030 |
| 7/05 | 1,653 | 10,320 | 11,973 | 40,934 | 0.042 |
| 7/06 | 2,698 | 18,546 | 21,244 | 62,178 | 0.064 |
| 7/07 | 1,170 | 15,791 | 16,961 | 79,138 | 0.081 |
| 7/08 | 1,488 | 16,420 | 17,908 | 97,046 | 0.100 |
| 7/09 | 2,607 | 24,118 | 26,725 | 123,771 | 0.127 |
| 7/10 | 4,922 | 32,479 | 37,401 | 161,172 | 0.166 |
| 7/11 | 20,394 | 33,416 | 53,809 | 214,982 | 0.221 |
| 7/12 | 29,022 | 34,324 | 63,346 | 278,328 | 0.286 |
| 7/13 | 35,024 | 38,495 | 73,518 | 351,846 | 0.362 |
| 7/14 | 32,874 | 42,058 | 74,932 | 426,778 | 0.439 |
| 7/15 | 29,459 | 24,421 | 53,881 | 480,658 | 0.494 |
| 7/16 [c] | 20,098 | 22,636 | 42,734 | 523,392 | 0.538 |
| 7/17 | 19,844 | 31,215 | 51,059 | 574,451 | 0.590 |
| 7/18 | 19,425 | 24,869 | 44,294 | 618,745 | 0.636 |
| 7/19 | 13,843 | 33,422 | 47,265 | 666,011 | 0.684 |
| 7/20 | 9,122 | 30,011 | 39,133 | 705,144 | 0.725 |
| 7/21 [d] | 9,816 | 40,635 | 50,451 | 755,595 | 0.776 |
| 7/22 | 13,290 | 57,545 | 70,835 | 826,430 | 0.849 |
| 7/23 | 7,467 | 38,764 | 46,231 | 872,661 | 0.897 |
| 7/24 | 13,466 | 22,474 | 35,940 | 908,600 | 0.934 |
| 7/25 | 10,579 | 26,215 | 36,794 | 945,395 | 0.971 |
| 7/26 | 11,889 | 15,970 | 27,859 | 973,254 | 1.000 |
| Total | 315,513 | 657,740 | 973,254 | 973,254 | |

*Note*: The large box indicates the central 50% of the pink salmon run (second and third quartiles).

[a] First day of tower counts.

[b] First quarter point.

[c] Midpoint.

[d] Third quarter point.

Table 5.–Annual passage estimates and passage timing for pink salmon runs (even years), at the Anvik River sonar, 1994–2014.

| | | | | | | Days between | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Sonar passage estimate | First count | First quartile | Median | Third quartile | First count & first quartile | First quartile & median | Median & third quartile | First &third quartile |
| 1994 | 252,999 | 6/27 | 7/18 | 7/20 | 7/22 | 21 | 2 | 2 | 4 |
| 1996[a,b] | ND | 7/1 | ND | ND | ND | ND | ND | ND | ND |
| 1998[c] | 146,095 | 7/12 | 7/17 | 7/20 | 7/22 | 5 | 3 | 2 | 5 |
| 2000 | 24,859 | 7/7 | 7/13 | 7/16 | 7/21 | 6 | 3 | 5 | 8 |
| 2002 | 131,482 | 6/30 | 7/10 | 7/13 | 7/15 | 10 | 3 | 2 | 5 |
| 2004 | 4,512 | 7/5 | 7/17 | 7/19 | 7/22 | 12 | 2 | 3 | 5 |
| 2006[d,b] | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 2008 | 734,837 | 6/29 | 7/15 | 7/19 | 7/22 | 16 | 4 | 3 | 7 |
| 2010[e] | 505,509 | 6/30 | 7/10 | 7/15 | 7/21 | 10 | 5 | 6 | 11 |
| 2012 | 591,387 | 7/1 | 7/7 | 7/17 | 7/21 | 6 | 10 | 4 | 14 |
| 2014 | 973,254 | 6/26 | 7/4 | 7/16 | 7/21 | 16 | 4 | 5 | 9 |
| Average | 280,698 | 7/1 | 7/12 | 7/17 | 7/20 | 10 | 4 | 4 | 8 |
| Median | 379,254 | 6/30 | 7/13 | 7/17 | 7/21 | 10 | 3 | 3 | 7 |
| SD[b] | 269,077 | 3.2 | 3.8 | 2.3 | 2.3 | 5.1 | 2.3 | 1.4 | 3.1 |

*Note*: ND = No data

[a] Total pink salmon passage was not estimated.

[b] Because of missing data and incomplete passage estimates in 1996, 1998, and 2006, run timing statistics were excluded from the calculation of the overall mean, timing statistics, and associated standard deviation (SD).

[c] Because of high turbid water, tower counts used to apportion pink and chum salmon were delayed until July 12.

[d] No data available for 2006.

[e] First year flash panels were deployed to help apportion run.

Table 6.–Number of minutes by bank and day that were adjusted to calculate the daily salmon passage, and the resulting number of fish added to the estimate, Anvik River sonar, 2014.

| | Left bank | | Right bank | |
|---|---|---|---|---|
| Date | Minutes | Fish | Minutes | Fish |
| 6/17 | 0 | 0 | 0 | 0 |
| 6/18 | 60 | 20 | 0 | 0 |
| 6/19 | 0 | 0 | 60 | 46 |
| 6/20 | 0 | 0 | 0 | 0 |
| 6/21 | 0 | 0 | 0 | 0 |
| 6/22 | 60 | 200 | 0 | 0 |
| 6/23 | 0 | 0 | 0 | 0 |
| 6/24 | 0 | 0 | 0 | 0 |
| 6/25 | 0 | 0 | 0 | 0 |
| 6/26 | 0 | 0 | 0 | 0 |
| 6/27 | 0 | 0 | 0 | 0 |
| 6/28 | 0 | 0 | 0 | 0 |
| 6/29 | 0 | 0 | 0 | 0 |
| 6/30 | 0 | 0 | 0 | 0 |
| 7/01 | 0 | 0 | 0 | 0 |
| 7/02 | 0 | 0 | 0 | 0 |
| 7/03 | 0 | 0 | 0 | 0 |
| 7/04 | 60 | 593 | 0 | 0 |
| 7/05 | 0 | 0 | 0 | 0 |
| 7/06 | 0 | 0 | 30 | 1,368 |
| 7/07 | 0 | 0 | 0 | 0 |
| 7/08 | 30 | 106 | 0 | 0 |
| 7/09 | 0 | 0 | 0 | 0 |
| 7/10 | 0 | 0 | 0 | 0 |
| 7/11 | 0 | 0 | 30 | 1,773 |
| 7/12 | 30 | 1,209 | 30 | 1,773 |
| 7/13 | 390 | 21,492 | 0 | 0 |
| 7/14 | 0 | 0 | 30 | 1,673 |
| 7/15 | 0 | 0 | 0 | 0 |
| 7/16 | 30 | 1,176 | 0 | 0 |
| 7/17 | 0 | 0 | 0 | 0 |
| 7/18 | 0 | 0 | 0 | 0 |
| 7/19 | 0 | 0 | 0 | 0 |
| 7/20 | 0 | 0 | 0 | 0 |
| 7/21 | 0 | 0 | 30 | 1,511 |
| 7/22 | 0 | 0 | 0 | 0 |
| 7/23 | 0 | 0 | 0 | 0 |
| 7/24 | 60 | 1,508 | 120 | 4,297 |
| 7/25 | 90 | 855 | 0 | 0 |
| 7/26 | 0 | 0 | 0 | 0 |
| Total | 810 | 27,159 | 330 | 12,441 |

Table 7.–Salmon species and proportion of summer chum salmon observed during tower counts by day and bank at the Anvik River sonar, 2014.

| | Left bank | | | | Right bank | | | |
|---|---|---|---|---|---|---|---|---|
| Date | Chum | Chinook | Pink | Proportion of chum | Chum | Chinook | Pink | Proportion of chum |
| 6/20 [a] | 0 | 0 | 0 | 0.00 | 0 | 0 | 0 | 0.00 |
| 6/21 | 5 | 0 | 0 | 1.00 | 5 | 0 | 0 | 1.00 |
| 6/22 | 0 | 0 | 0 | 0.00 | 0 | 0 | 0 | 0.00 |
| 6/23 | 5 | 0 | 0 | 1.00 | 0 | 0 | 0 | 0.00 |
| 6/24 | 4 | 0 | 0 | 1.00 | 60 | 0 | 0 | 1.00 |
| 6/25 | 0 | 0 | 0 | 0.00 | 150 | 0 | 0 | 1.00 |
| 6/26 | 8 | 0 | 1 | 0.89 | 302 | 1 | 8 | 0.97 |
| 6/27 | 18 | 0 | 0 | 1.00 | 237 | 0 | 17 | 0.93 |
| 6/28 | 62 | 0 | 1 | 0.98 | 267 | 0 | 16 | 0.94 |
| 6/29 | 29 | 0 | 1 | 0.97 | 100 | 0 | 19 | 0.84 |
| 6/30 | 80 | 0 | 5 | 0.94 | 566 | 1 | 64 | 0.90 |
| 7/01 | 120 | 0 | 15 | 0.89 | 1,168 | 8 | 121 | 0.90 |
| 7/02 | 16 | 0 | 4 | 0.80 | 294 | 1 | 47 | 0.86 |
| 7/03 | 32 | 0 | 26 | 0.55 | 495 | 3 | 148 | 0.77 |
| 7/04 | 42 | 2 | 28 | 0.58 | 1,070 | 28 | 344 | 0.74 |
| 7/05 | 26 | 0 | 25 | 0.51 | 691 | 18 | 339 | 0.66 |
| 7/06 | 114 | 1 | 95 | 0.54 | 787 | 37 | 589 | 0.56 |
| 7/07 | 26 | 0 | 20 | 0.57 | 582 | 29 | 475 | 0.54 |
| 7/08 | 10 | 0 | 15 | 0.40 | 293 | 16 | 498 | 0.36 |
| 7/09 | 18 | 0 | 23 | 0.44 | 301 | 7 | 529 | 0.36 |
| 7/10 | 105 | 0 | 222 | 0.32 | 229 | 10 | 548 | 0.29 |
| 7/11 | 25 | 1 | 396 | 0.06 | 254 | 2 | 559 | 0.31 |
| 7/12 | 248 | 2 | 847 | 0.23 | 135 | 2 | 910 | 0.13 |
| 7/13 | 64 | 1 | 1,062 | 0.06 | 195 | 3 | 751 | 0.21 |
| 7/14 | 14 | 2 | 522 | 0.03 | 109 | 1 | 504 | 0.18 |
| 7/15 | 25 | 1 | 537 | 0.04 | 79 | 1 | 348 | 0.18 |
| 7/16 | 26 | 0 | 720 | 0.03 | 153 | 8 | 386 | 0.28 |
| 7/17 | 19 | 1 | 557 | 0.03 | 133 | 6 | 763 | 0.15 |
| 7/18 | 34 | 0 | 1,106 | 0.03 | 59 | 1 | 422 | 0.12 |
| 7/19 | 24 | 0 | 519 | 0.04 | 34 | 0 | 373 | 0.08 |

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Table 7.–Page 2 of 2.

| | Left Bank | | | | Right Bank | | | |
|---|---|---|---|---|---|---|---|---|
| Date | Chum | Chinook | Pink | Proportion of chum | Chum | Chinook | Pink | Proportion of chum |
| 7/20 | 6 | 0 | 351 | 0.02 | 39 | 0 | 567 | 0.06 |
| 7/21 | 3 | 0 | 125 | 0.02 | 25 | 0 | 358 | 0.07 |
| 7/22 | 9 | 1 | 355 | 0.02 | 76 | 2 | 1,438 | 0.05 |
| 7/23 | 44 | 0 | 346 | 0.11 | 11 | 1 | 452 | 0.02 |
| 7/24 | 4 | 0 | 224 | 0.02 | 20 | 0 | 215 | 0.09 |
| 7/25 | 5 | 0 | 247 | 0.02 | 35 | 0 | 376 | 0.09 |

[a] First day of tower counts.

Table 8.–Age and sex composition of summer chum salmon, Anvik River sonar, 2014.

| Sample dates (Strata) | Samples (*n*) | Sex | Brood year (age) 2011 (0.2) Estimate | % | 2010 (0.3) Estimate | % | 2009 (0.4) Estimate | % | 2008 (0.5) Estimate | % | Total Estimate | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6/27-29 | 31 | Male | 0 | 0 | 9,430 | 9.7 | 31,433 | 32.3 | 6,287 | 6.5 | 47,149 | 48.4 |
| (6/17-30) | | Female | 0 | 0 | 12,573 | 12.9 | 31,433 | 32.3 | 6,287 | 6.5 | 50,293 | 51.6 |
| | | Subtotal | 0 | 0 | 22,003 | 22.6 | 62,866 | 64.5 | 12,573 | 12.9 | 97,442 | 100 |
| 7/01-03 | 78 | Male | 0 | 0 | 25,544 | 21.8 | 24,042 | 20.5 | 3,005 | 2.6 | 52,591 | 44.9 |
| (7/01-05) | | Female | 0 | 0 | 24,042 | 20.5 | 33,057 | 28.2 | 7,513 | 6.4 | 64,612 | 55.1 |
| | | Subtotal | 0 | 0 | 49,586 | 42.3 | 57,099 | 48.7 | 10,518 | 9 | 117,203 | 100 |
| 7/08-09, 12, 14 | 43 | Male | 0 | 0 | 47,364 | 25.6 | 30,141 | 16.3 | 4,306 | 2.3 | 81,811 | 44.2 |
| (7/09-15) | | Female | 0 | 0 | 60,282 | 32.6 | 43,058 | 23.3 | 0 | 0 | 103,340 | 55.8 |
| | | Subtotal | 0 | 0 | 107,646 | 58.1 | 73,199 | 39.5 | 4,306 | 2.3 | 185,151 | 100 |
| Season | 152 | Male | 0 | 0 | 82,338 | 20.6 | 85,615 | 21.4 | 13,598 | 3.4 | 181,551 | 45.4 |
| | | Female | 0 | 0 | 96,897 | 24.2 | 107,549 | 26.9 | 13,800 | 3.5 | 218,245 | 54.6 |
| | | Total | 0 | 0 | 179,235 | 44.8 | 193,164 | 48.3 | 27,397 | 6.9 | 399,796 | 100.0 |

*Note:* Number fish per strata and age class is based on the sonar estimate multiplied by percent of fish in age class.

Table 9.–Anvik River summer chum salmon brood table with return per spawner 1972 to present.

| | | Number of fish by age class [a] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Brood year | Escapement | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | Total return | R/S |
| 1972 | 457,800 | 33,937 | 158,275 | 31,081 | 1,690 | 0 | 224,983 | 0.49 |
| 1973 | 249,015 | 38,108 | 420,521 | 126,898 | 3,021 | 0 | 588,547 | 2.36 |
| 1974 | 411,133 | 121,303 | 576,013 | 166,630 | 0 | 0 | 863,946 | 2.10 |
| 1975 | 900,967 | 25,117 | 420,779 | 79,920 | 13,743 | 0 | 539,558 | 0.60 |
| 1976 | 511,475 | 46,139 | 847,858 | 1,252,710 | 10,952 | 0 | 2,157,659 | 4.22 |
| 1977 | 358,771 | 5,016 | 741,317 | 216,540 | 6,378 | 0 | 969,250 | 2.70 |
| 1978 | 307,270 | 1,879 | 475,533 | 355,167 | 2,118 | 0 | 834,697 | 2.72 |
| 1979 | 277,712 | 28,248 | 425,230 | 182,323 | 6,476 | 0 | 642,277 | 2.31 |
| 1980 | 482,181 | 6,721 | 1,027,086 | 335,068 | 22,000 | 0 | 1,390,875 | 2.88 |
| 1981 | 1,479,582 | 25,347 | 1,028,684 | 1,131,492 | 36,613 | 0 | 2,222,135 | 1.50 |
| 1982 | 444,581 | 25,717 | 489,890 | 227,736 | 15,193 | 0 | 758,537 | 1.71 |
| 1983 | 362,912 | 5,295 | 460,582 | 356,962 | 4,197 | 0 | 827,037 | 2.28 |
| 1984 | 89,1028 | 8,424 | 1,354,563 | 762,877 | 12,465 | 0 | 2,138,329 | 2.40 |
| 1985 | 1,080,243 | 65,276 | 446,452 | 255,665 | 4,925 | 0 | 772,318 | 0.71 |
| 1986 | 1,189,602 | 8,530 | 338,004 | 604,033 | 41,841 | 0 | 992,407 | 0.83 |
| 1987 | 455,876 | 13,501 | 480,033 | 697,632 | 15,804 | 22 | 1,206,993 | 2.65 |
| 1988 | 1,125,449 | 840 | 267,719 | 214,012 | 16,142 | 0 | 498,714 | 0.44 |
| 1989 | 636,906 | 2,520 | 374,740 | 780,541 | 73,620 | 238 | 1,231,658 | 1.93 |
| 1990 | 403,627 | 3,379 | 441,397 | 676,695 | 26,148 | 23 | 1,147,643 | 2.84 |
| 1991 | 847,772 | 22 | 844,961 | 534,460 | 14,516 | 0 | 1,393,960 | 1.64 |
| 1992 | 775,626 | 39,076 | 630,294 | 404,043 | 7,591 | 7 | 1,081,012 | 1.39 |
| 1993 | 517,409 | 5,312 | 292,425 | 103,577 | 5,632 | 0 | 406,946 | 0.79 |
| 1994 | 1,147,262 | 3,269 | 424,089 | 301,083 | 4,487 | 0 | 732,928 | 0.64 |
| 1995 | 1,394,162 | 129 | 172,419 | 62,925 | 5,397 | 0 | 240,870 | 0.17 |
| 1996 | 1,017,873 | 92 | 158,411 | 210,835 | 8,828 | 0 | 378,166 | 0.37 |
| 1997 | 619,300 | 1,767 | 33,796 | 104,599 | 4,284 | 0 | 144,446 | 0.23 |
| 1998 | 487,301 | 0 | 369,505 | 72,451 | 1,928 | 0 | 443,884 | 0.91 |
| 1999 | 437,356 | 8,894 | 203,268 | 226,119 | 3,467 | 0 | 441,748 | 1.01 |

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Table 9.–Page 2 of 2.

| Brood year | Escapement | Number of fish by age class [a] 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | Total return | R/S |
|---|---|---|---|---|---|---|---|---|
| 2000 | 196,349 | 3,141 | 164,193 | 165,669 | 172 | 81 | 333,257 | 1.70 |
| 2001 | 224,058 | 10,106 | 547,217 | 630,375 | 59,123 | 88 | 1,246,909 | 5.57 |
| 2002 | 459,058 | 179 | 406,630 | 197,377 | 21,692 | 156 | 626,034 | 1.36 |
| 2003 | 256,920 | 12,951 | 315,016 | 240,519 | 10,003 | 0 | 578,490 | 2.25 |
| 2004 | 365,353 | 5,061 | 199,985 | 120,668 | 1,290 | 0 | 327,004 | 0.90 |
| 2005 | 525,391 | 6,087 | 161,296 | 63,681 | 6,130 | 0 | 237,193 | 0.45 |
| 2006 | 992,378 | 5,915 | 420,978 | 394,426 | 8,207 | 0 | 829,526 | 0.84 |
| 2007 | 460,121 | 35,346 | 402,640 | 177,568 | 4,815 | 168 | 620,537 | 1.35 |
| 2008 | 374,928 | 2,733 | 441,160 | 534,015 | 11,059 | 0 | 988,968 | 2.64 |
| 2009 | 193,099 | 3,511 | 270,371 | 356,656 | | | | |
| 2010 | 396,173 | 0 | 261,455 | | | | | |
| 2011 | 642,528 | 873 | | | | | | |
| 2012 | 483,972 | | | | | | | |
| 2013 | 577,877 | | | | | | | |
| 2014 | 399,223 | | | | | | | |

[a] Includes a proportion of the commercial catch from Districts 1 to 4 destined for Anvik River.

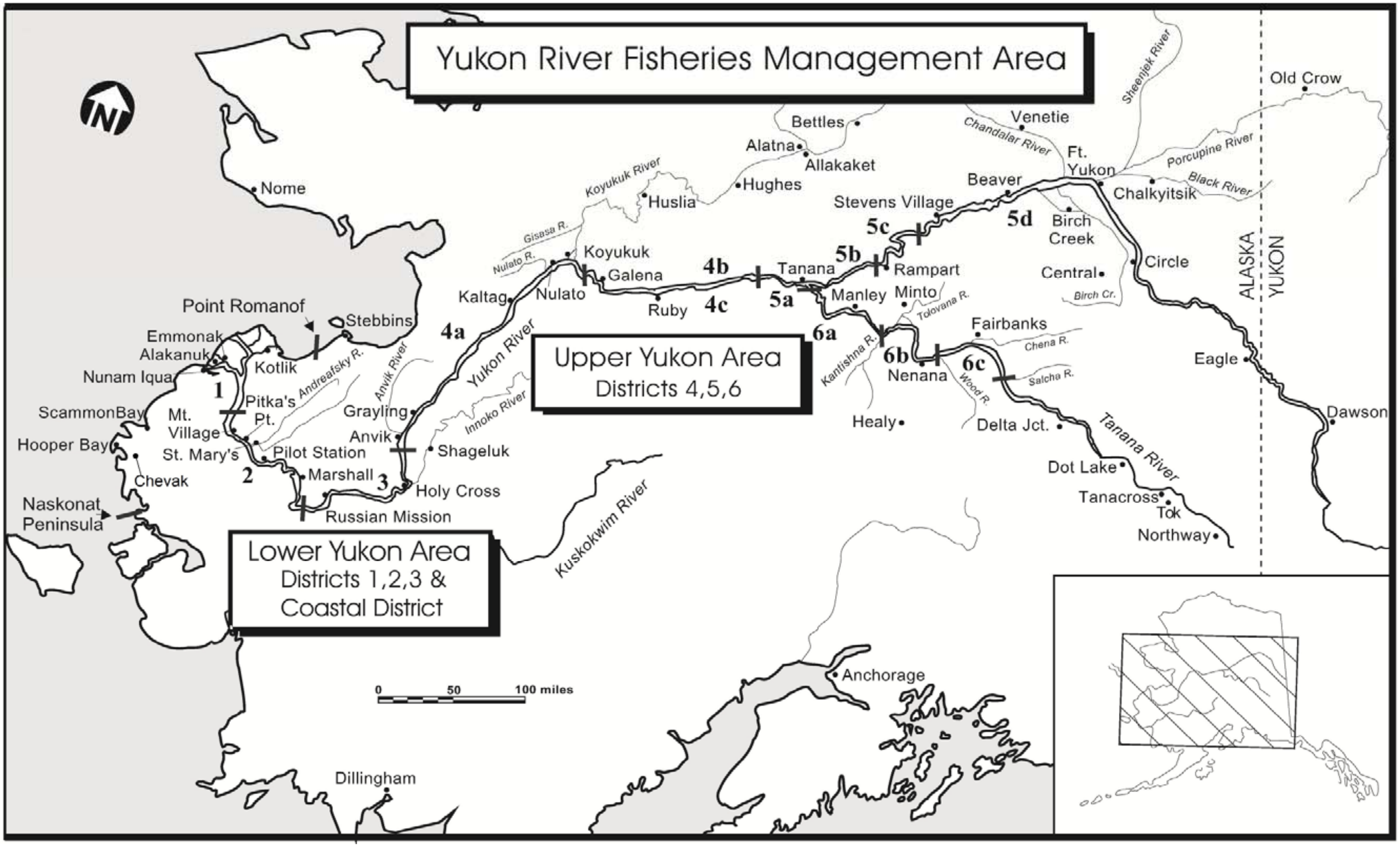


Figure 1.–Alaska portion of the Yukon River drainage showing communities and fishing districts.

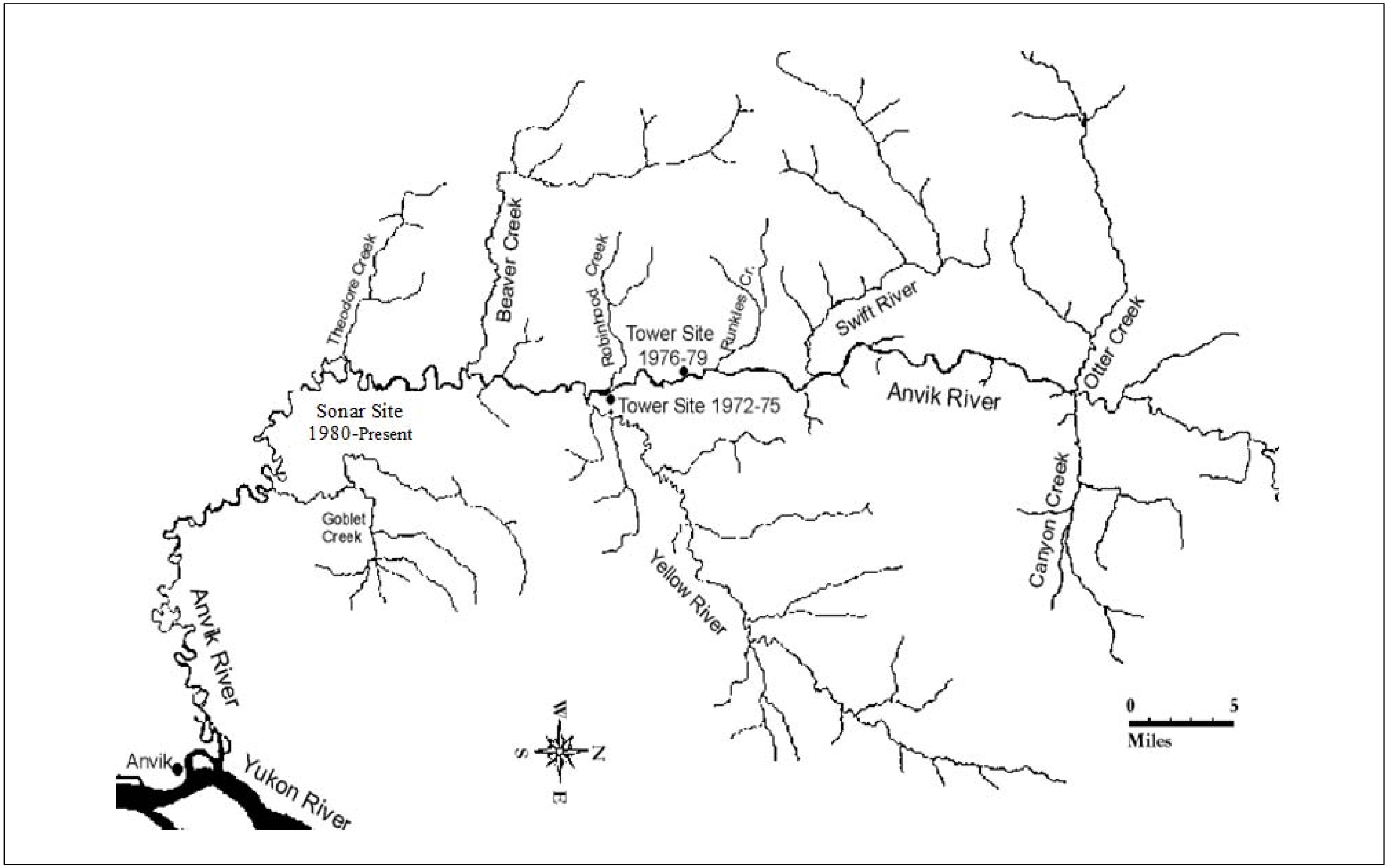


Figure 2.–Anvik River drainage with historical chum salmon escapement project locations.

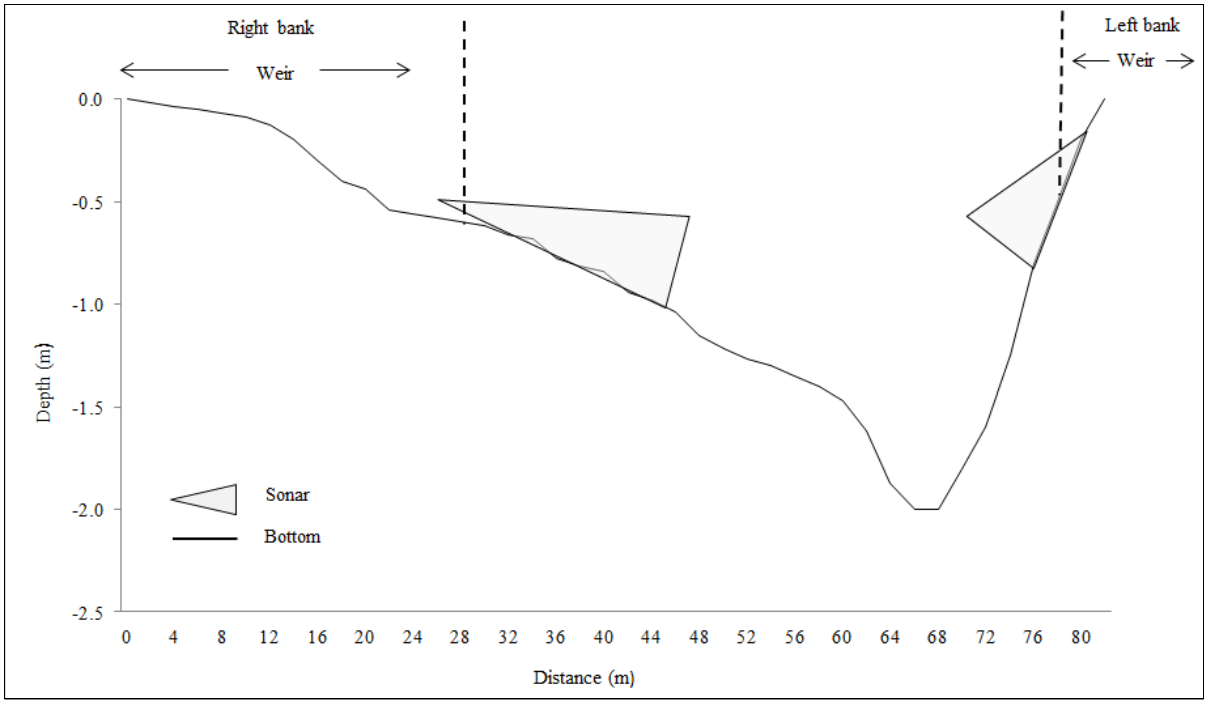


Figure 3.–Depth profile of the Anvik River (upstream view), and approximate sonar ranges (not to scale) at the Anvik River sonar project, 2014.

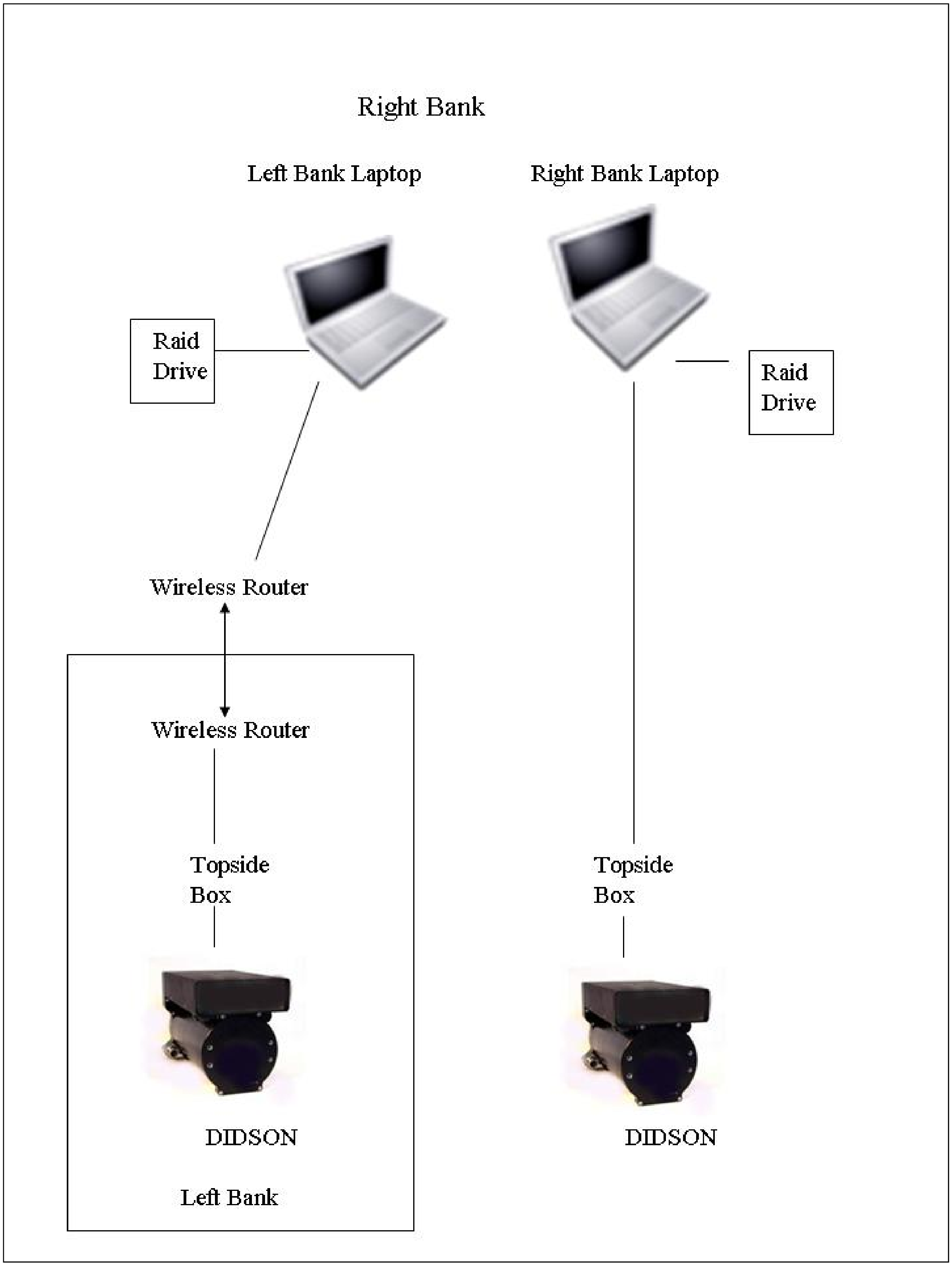


Figure 4.–DIDSON sonar equipment schematic, Anvik River sonar, 2014.

*Note*: Both the left bank and right back laptops are housed in the right bank sonar tent.

Figure 5.–View of a DIDSON mounted to aluminum H-mount with manual crank-style rotator at the Sheenjek sonar project.

*Note*: This mount is comparable to the one used at the Anvik sonar project, on the Anvik River.

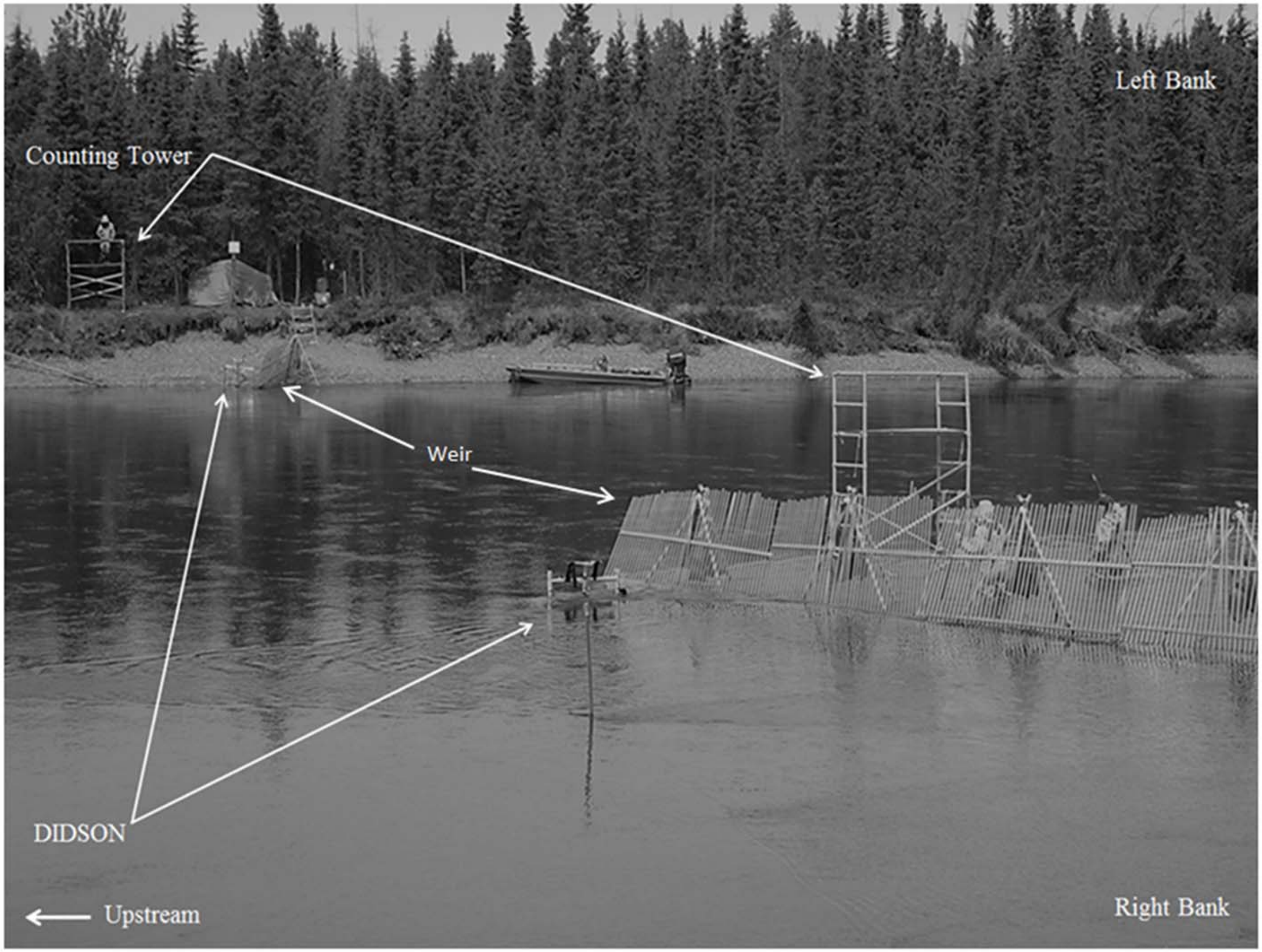


Figure 6.–Anvik River sonar site, illustrating locations of sonars, weirs, and counting towers on the Anvik River, 2014.

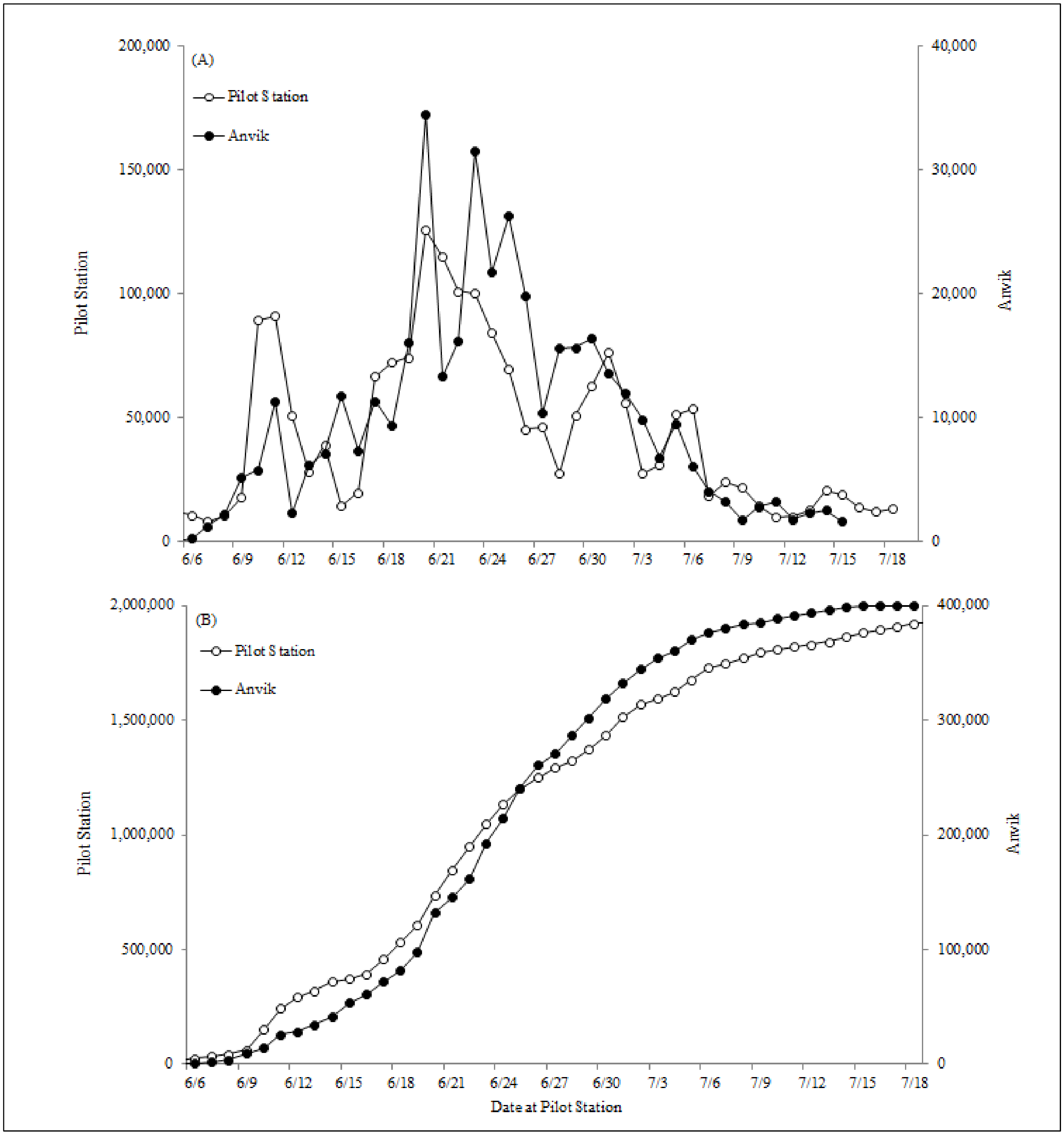


Figure 7.–Daily summer chum salmon passage at the Anvik River sonar and the sonar project near the village of Pilot Station (A), and cumulative summer chum salmon passage at both projects (B), 2014.

*Note*: The timing of Anvik summer chum salmon is lagged back 11 days to align with Pilot Station.

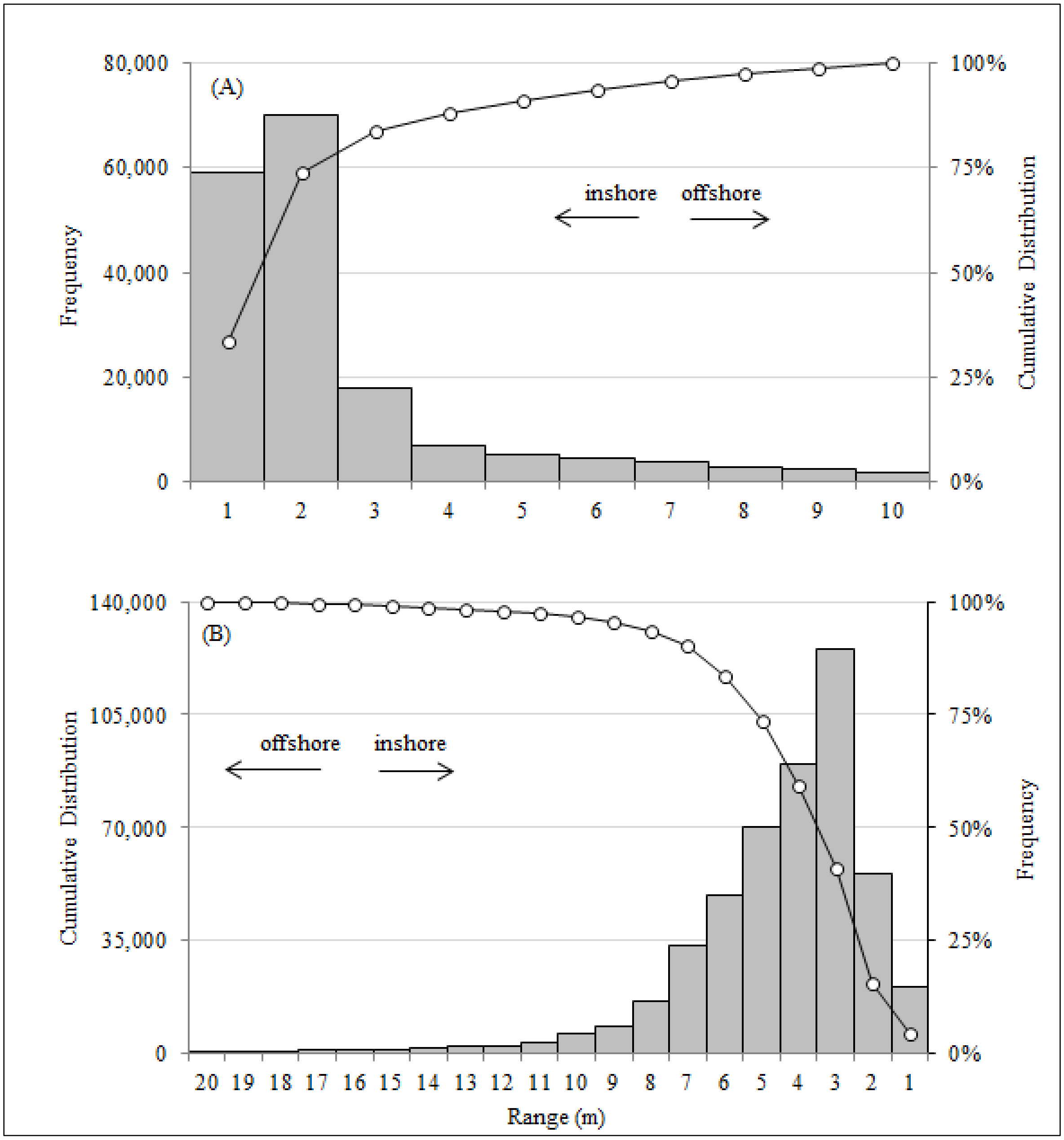


Figure 8.–Left bank (A) and right bank (B) horizontal distribution of upstream salmon passage at the Anvik River sonar project, June 17 through July 26, 2014.

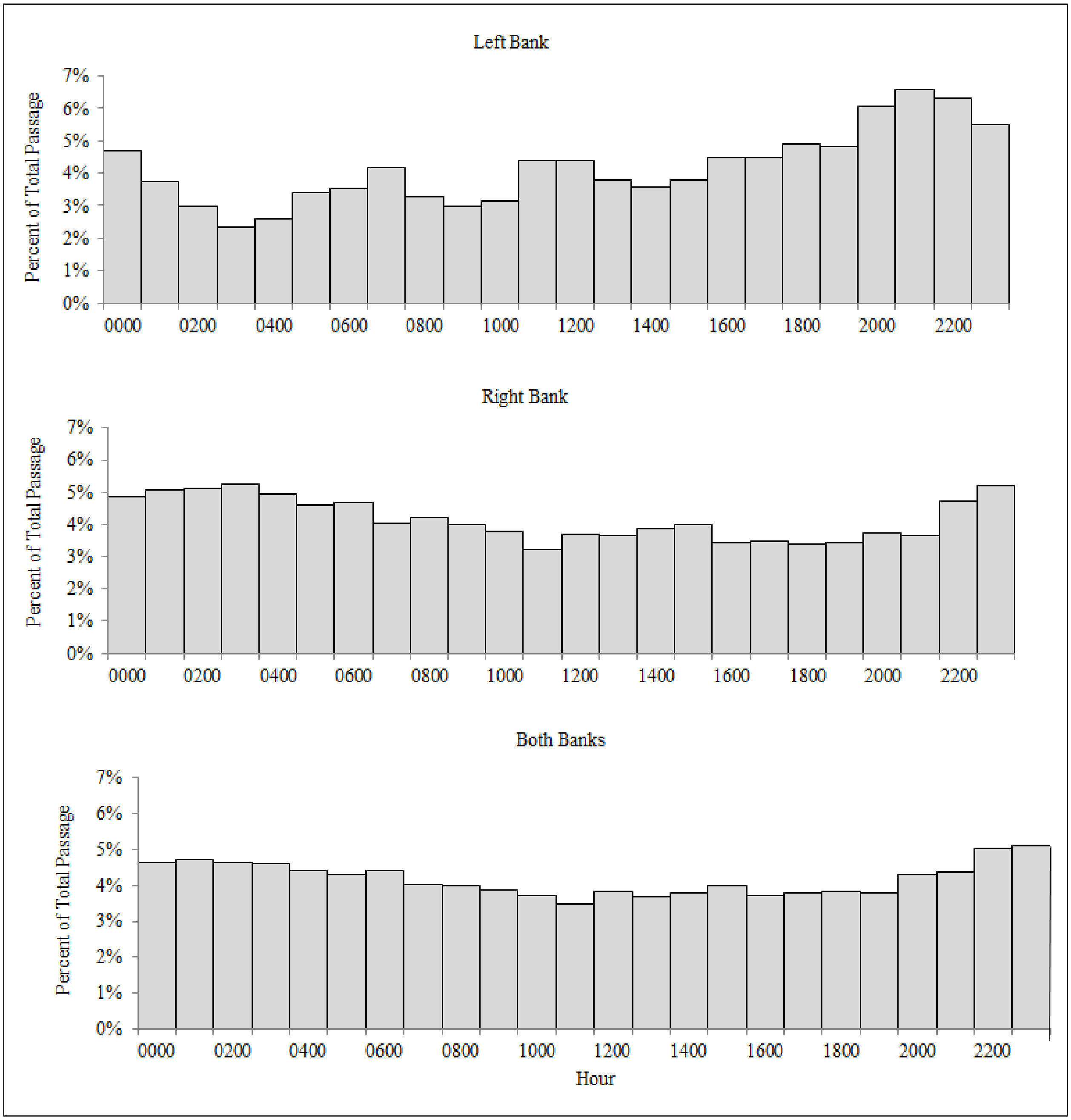


Figure 9.–Percentage of total passage, by hour, observed on the left bank (top), right bank (middle), and both banks combined (bottom) of the Anvik River at the Anvik sonar project site, 2014.

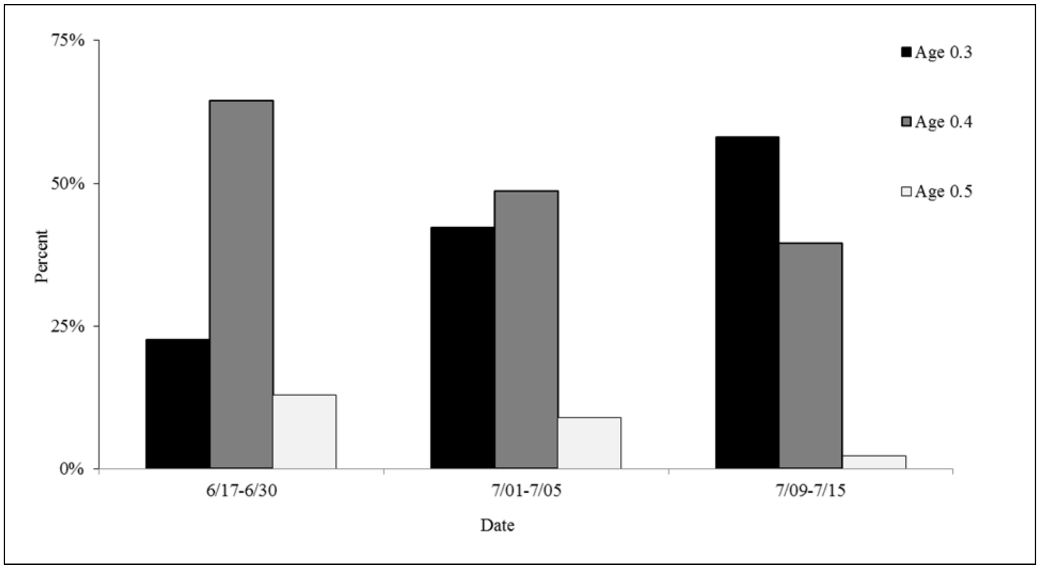

Figure 10.–Summer chum salmon age composition by sampling strata at the Anvik River sonar, 2014.

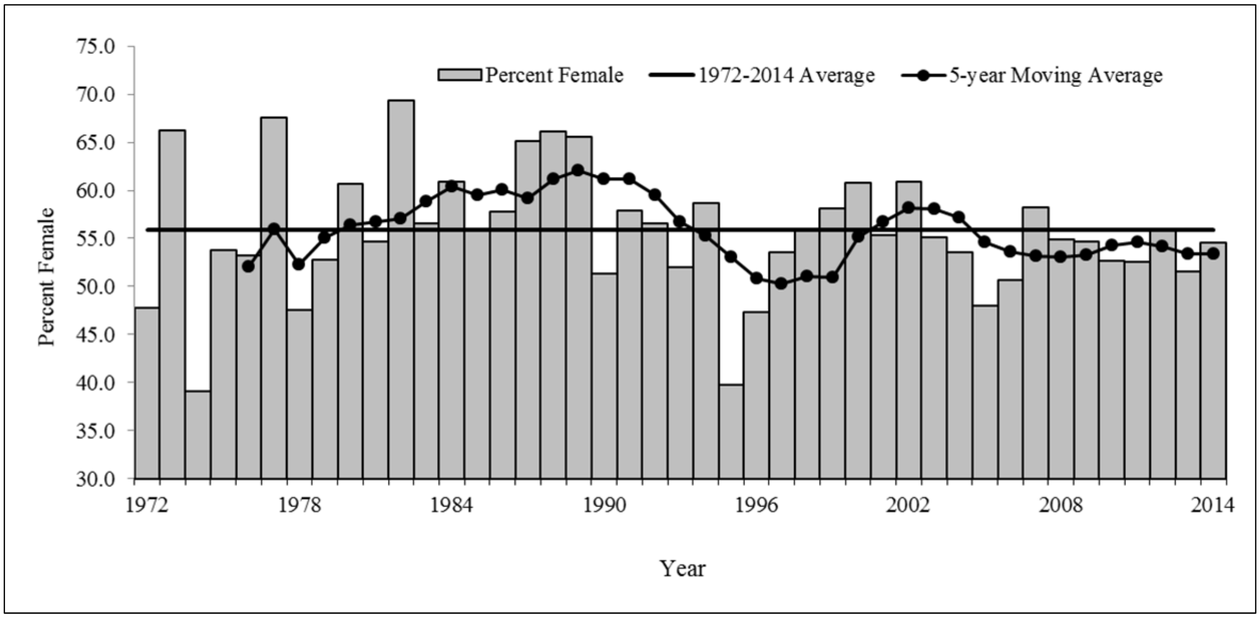


Figure 11.–Percent of female summer chum salmon escapement estimated at the Anvik River sonar project 1972–2014.

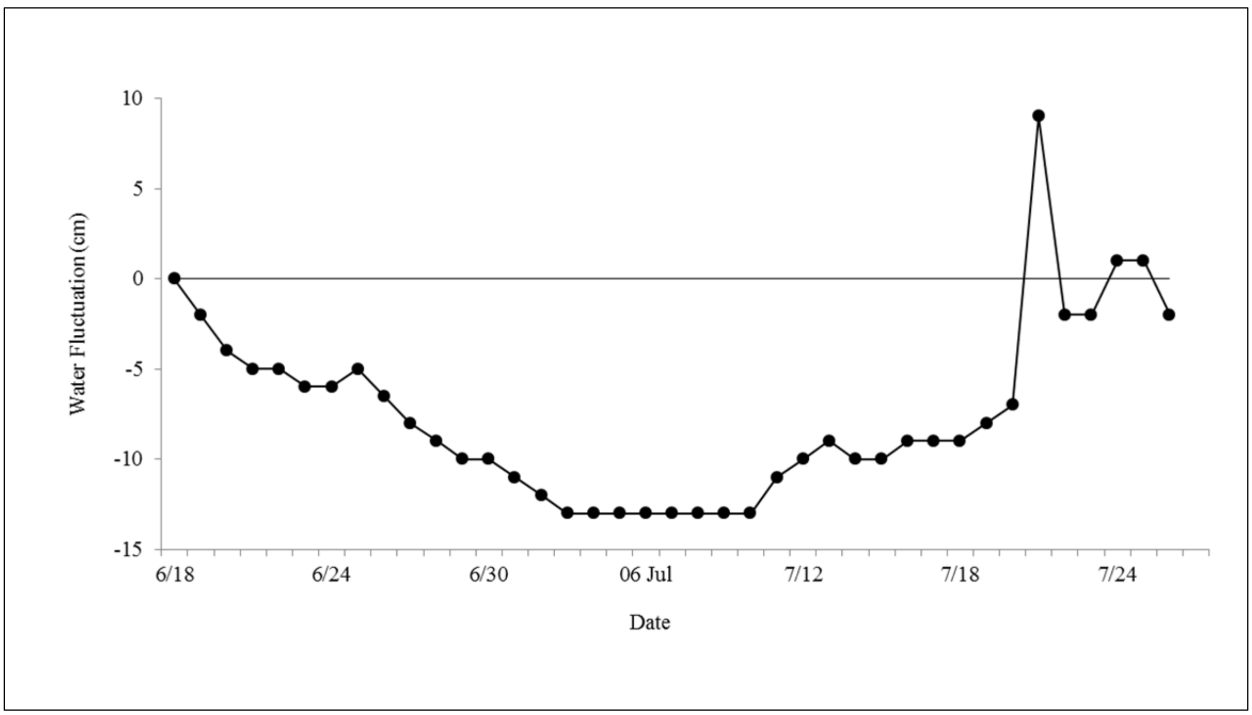


Figure 12.–Change in daily water elevation, relative to June 18, measured at the Anvik River sonar project, 2014.

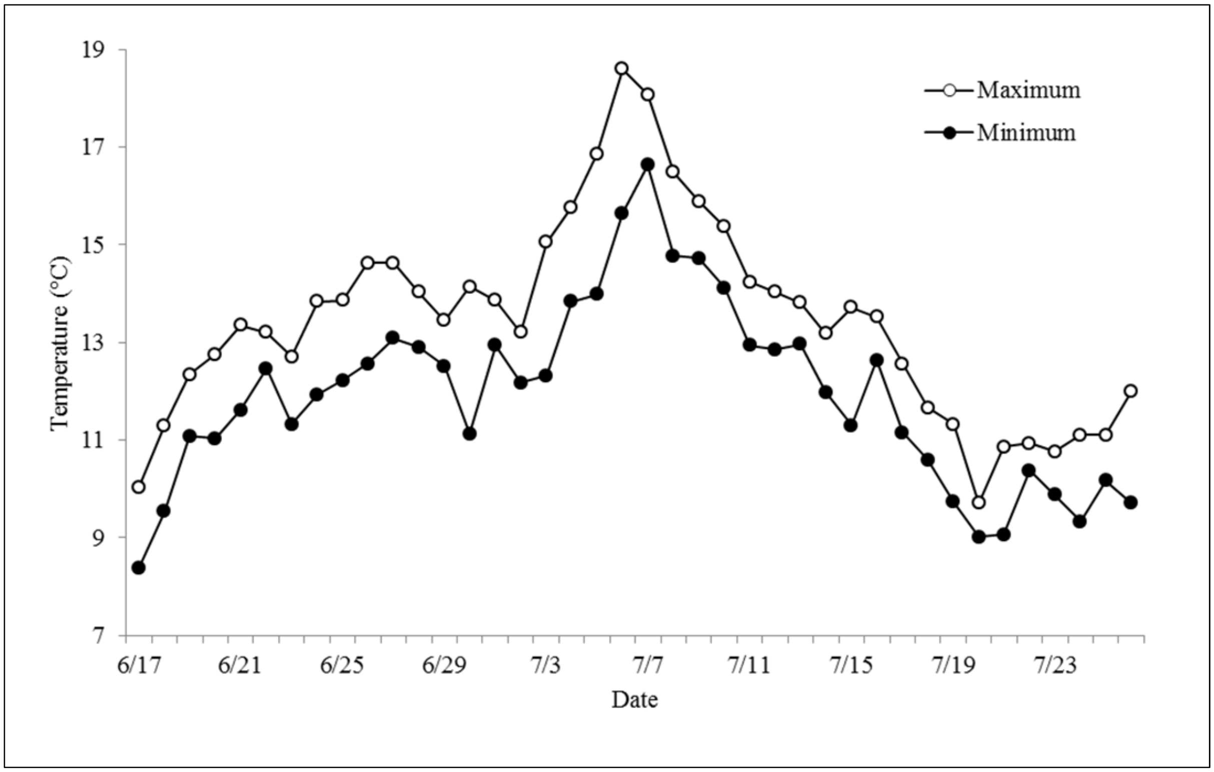


Figure 13.–Daily water temperatures at the Anvik River sonar, 2014.